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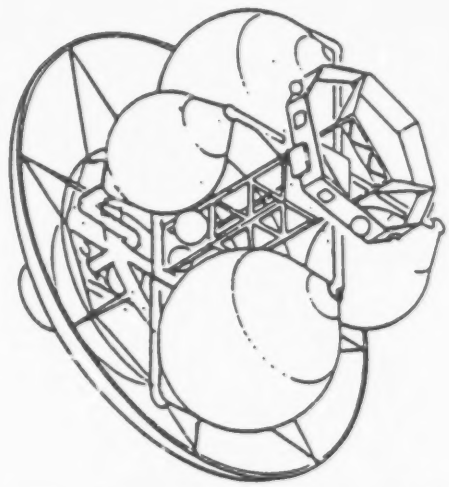
Work Breakdown Structure And Dictionary

Volume V

Orbital Transfer Vehicle Concept Definition And System Analysis Study 1985



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ORBITAL TRANSFER VEHICLE
CONCEPT DEFINITION AND SYSTEM ANALYSIS STUDY

VOLUME V
WORK BREAKDOWN STRUCTURE AND DICTIONARY

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FOREWORD

This final report, Volume V -- Work Breakdown Structure and Dictionary, was prepared by Martin Marietta Denver Aerospace for NASA/MSFC in accordance with contract NAS 8-36108. This original study was conducted under the direction of NASA OTV Study Manager, Mr. Donald R. Saxton, during the period from July 1984 to December 1986. The final reports are arranged into ten volumes:

Volume I	Executive Summary
Volume IA	Executive Summary Supplement
Volume II	OTV Concept Definition and Evaluation
	Book 1 Mission and System Requirements
	Book 2 OTV Concept Definition
	Book 3 Subsystem Trade Studies
	Book 4 Operations
Volume III	System and Program Trades
Volume IV	Space Station Accommodations
Volume V	Work Breakdown Structure and Dictionary
Volume VI	Cost Estimates
Volume VII	Integrated Technology Development Plan
Volume VIII	Environmental Analyses
Volume IX	Study Extension Results

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1.0 INTRODUCTION

To establish consistency and visibility within the Orbital Transfer Vehicle (OTV) program, a preliminary work breakdown structure (WBS) and dictionary were developed. The dictionary contains definitions of terms to be used in conjunction with the WBS so that a clear understanding of the content of the hardware, function, and cost elements may be established.

The OTV WBS matrix (Figure 1-1) is a two-dimensional structure which shows the interrelationship of these dimensions: the hardware elements dimension and the phase and function dimension.

The dimension of time cannot be shown graphically, but must be considered. Each cost entry varies with time so that it is necessary to know these cost values by year for budget planning and approval as well as for establishing cost streams for discounting purposes in the economic analysis.

While a multiple dimensional approach may at first appear complex, it actually provides benefits which outweigh any concern. This structural interrelationship provides the capability to view and analyze the OTV costs from a number of different financial and management aspects. Costs may be summed by hardware groupings, phases, functions, etc. The WBS may be used in a number of dimensional or single listing format applications.

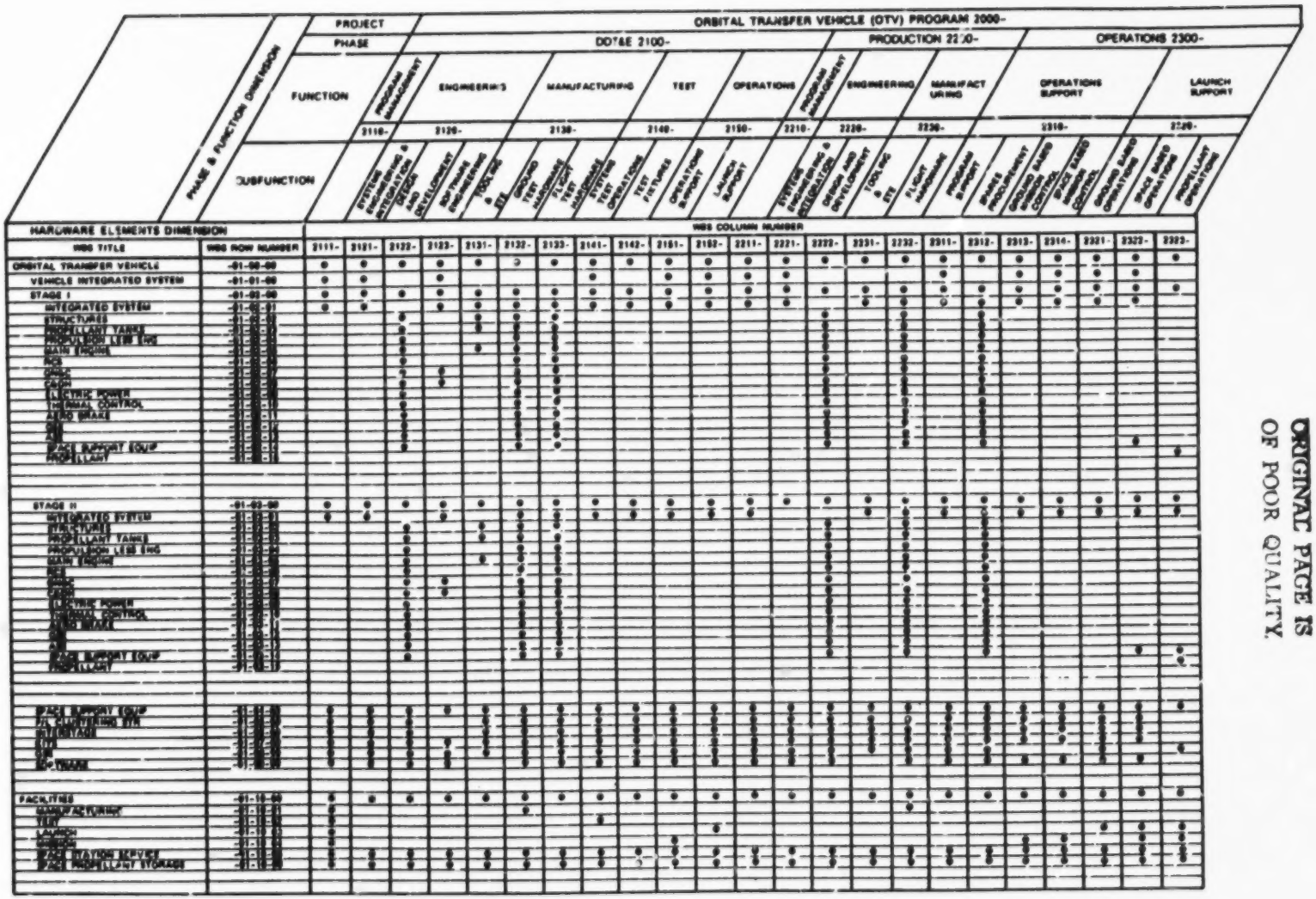

Figure 1-1 OTV Work Breakdown Structure Matrix Format

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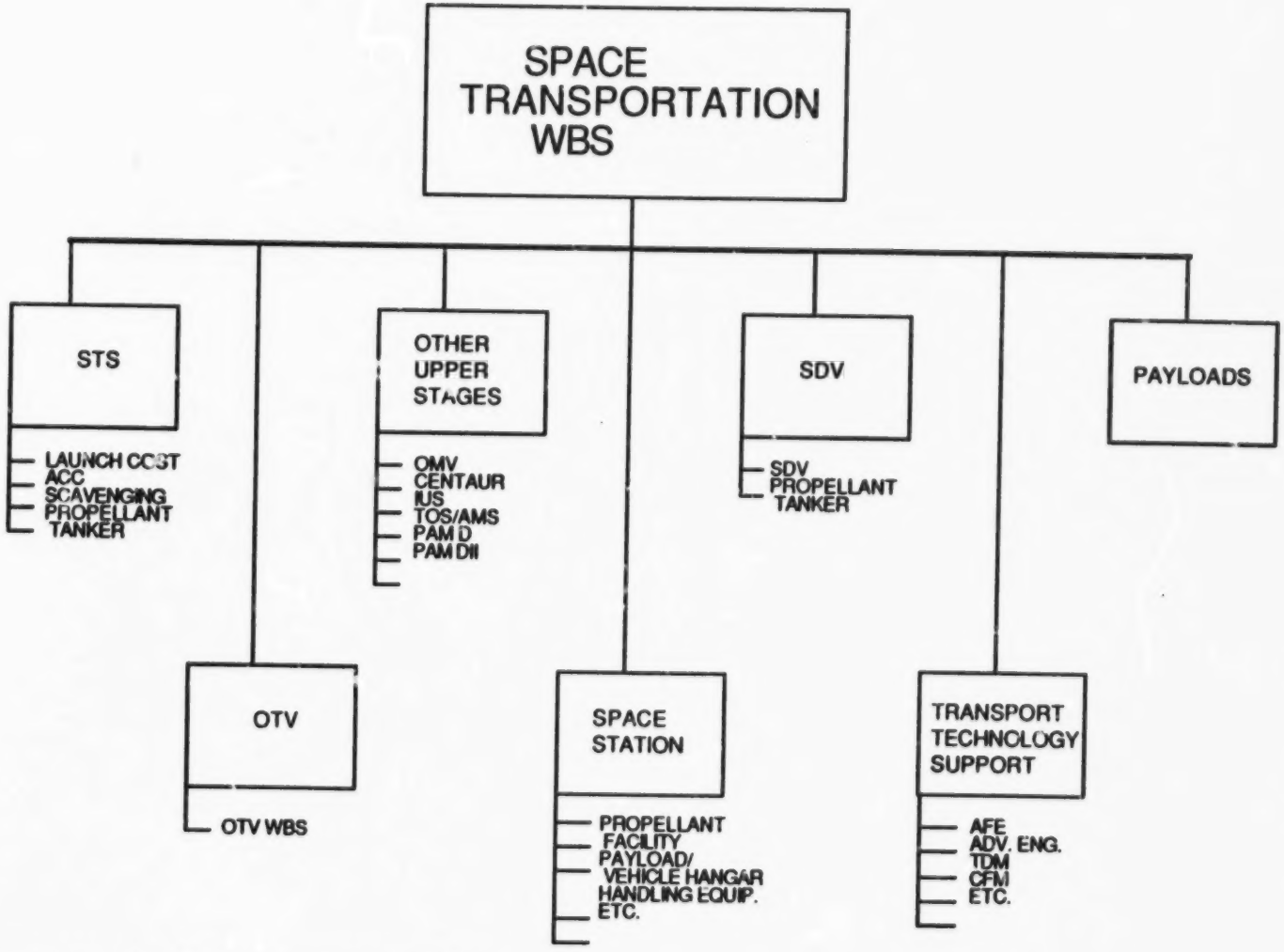

Figure 1-2 Space Transportation WBS

2.0 WBS ORGANIZATION

The OTV WBS is divided into:

1) A graphic display of the two-dimensional OTV WBS matrix (Figure 1-1);
2) A graphic display of the relationship of the OTV WBS with supporting program costs (Figure 1-2);
3) The hardware element dimension WBS (Figure 2-1) and the definition of terms;
4) The phase and function dimensions WBS's phase (Figures 5-1, 5-2 and 5-3) and the definitions of terms.

A systematic numerical coding system coordinates the rows of the hardware element dimension to the columns of the phase and function dimension such that all matrix locations are identifiable by WBS number.

In Figure 1, each mark (o) represents a matrix position that corresponds to an identifiable task that must be completed for the OTV. Each mark (o) also identifies a cost that will occur and must be accounted for.

Figure 1-2 shows the relationship of the OTV WBS to other components of the Space Transportation WBS. The OTV program will rely heavily on certain components of this WBS, especially the launch vehicle component.

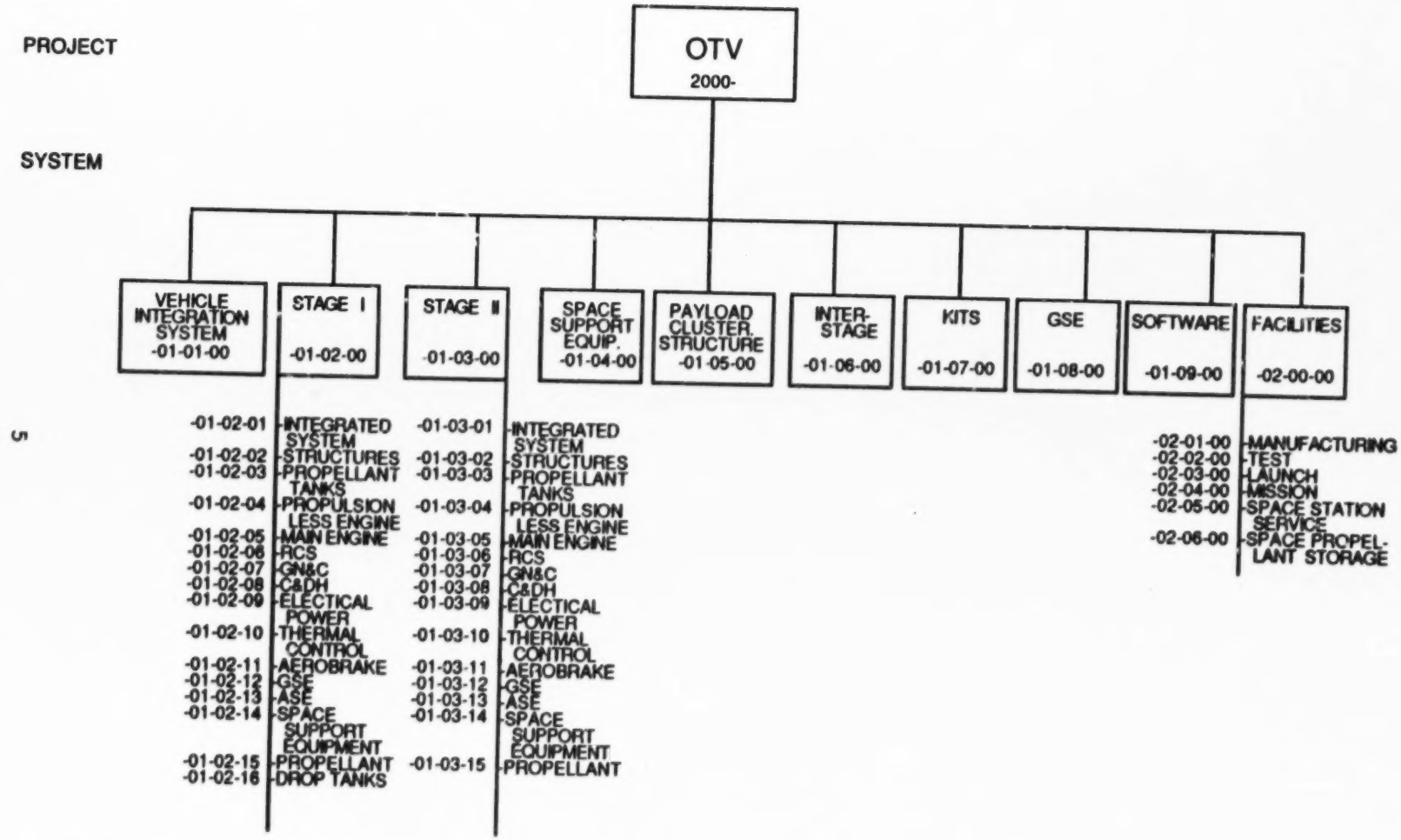

Figure 2-1 Hardware Element WBS -- Hardware Element Dimension

3.0 HARDWARE ELEMENTS DIMENSION

The hardware elements dimension contains all of the presently defined OTV hardware elements broken out into project, system/subsystem levels. Inherent within this dimension is the capability for further expansion to lower levels such as assemblies, subassemblies, components, etc., limited only by the realism of the requirements. A typical hardware element WBS is shown in Figure 2-1. Definitions of the individual elements are contained in the following pages.

4.0 WBS DICTIONARY

1.0.0 OTV

This hardware element is a summary level element composed of all efforts and materials required for design, development, production, and operation of the orbital transfer vehicle. This item includes those elements which are combined to provide a total system:

1.1.0 Vehicle Integrated Systems

1.2.0 Stage I

1.3.0 Stage II

1.4.0 Space Support Equipment

1.5.0 Payload Clustering Structure

1.6.0 Interstage

1.7.0 Kits

1.8.0 GSE

1.1.0 Vehicle Integrated System

This hardware element contains the hardware related efforts and materials required for design, development, production, and operation of the total vehicle which cannot be allocated to individual hardware elements below the vehicle level. It includes elements associated with the integration, test, system engineering, and management of the total OTV program.

1.2.0 Stage I

1.3.0 Stage II

1.2.1 Integrated Systems

1.3.1 " "

This hardware element contains the hardware related efforts and materials required for design, development, production, and operation of the total hardware category which cannot be allocated to individual hardware elements below the hardware category level. It includes elements associated with integration, test, system engineering, and program management of the total hardware category.

1.2.2 Structures

1.3.2 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Structures subsystem. This element includes the frame or body structure, trusses, support hardware and miscellaneous attach fittings.

1.2.3 Propellant Tanks

1.3.3 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Propellant Tank subsystem. This element contains the hardware associated with main propellant storage tanks and includes the tank shell structure and all items integral to the tank such as acquisition devices, baffles, connectors and valves. The propellant feed system elements between the engine interface and the propellant tankage interface are not included (see Propulsion Less Engines).

1.2.4 Propulsion Less Engines

1.3.4 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Propulsion subsystem. This element includes the propellant feed system elements between the engine interface and the propellant tankage interface, including such items as lines, valves, regulators, controls, tank venting systems, pressurization system, engine pneumatic system, and other engine accessories. The main thruster engines are not included (see Main Engine).

1.2.5 Main Engine

1.3.5 "

This hardware element sums all efforts and materials required for design, development, production, and operations of the Main Engine subsystem. This element contains the primary thruster engines only.

1.2.6 RCS

1.3.6 "

This hardware element sums all efforts and materials required for design, development, production, and operations of the Reaction Control subsystem. This element includes the RCS thrusters and the lines, valves, regulators, controls, tank venting systems, pressurization system and other accessories associated with the RCS system. RCS tanks are included in this element if different from the main propulsion storage tanks.

1.2.7 Guidance, Navigation and Control

1.3.7 "

This hardware element sums all efforts and materials required for design, development, production and operation of the Guidance, Navigation and Control subsystem. Typical hardware utilized by this subsystem are: inertial measurement units, rate gyro package and star tracker.

1.2.8 Command and Data Handling

1.3.8 "

This hardware element sums all efforts and materials required for design, development, production and operation of the Command and Data Handling subsystem. This element includes data management, flight instrumentation and communications hardware. Typical hardware utilized by this subsystem are: computers, recorder and storage units, data bus interface, signal conditioners, measuring equipment, antenna systems, tracking and command, telemetry, flight sensors and switching networks.

1.2.9 Electric Power

1.3.9 "

This hardware element sums all efforts and materials required for design, development, production, and operations of the Power subsystem. This element includes the electrical and/or hydraulic power for utilization by all vehicle subsystems. Typical hardware contained in this subsystem are generators, batteries, fuel cells, auxiliary power generators, hydraulic pumps, power converters and inverters, power distributors, hydraulic lines, valves, cables and wiring, power conditioners, and lights.

1.2.10 Thermal Control

1.3.10 "

This hardware element sums all efforts and materials required for design, development, production, and operations of the Thermal Control subsystem. This element contains the active and passive equipments necessary to provide an operating environment while on orbit and during aerobrake maneuvers. Thermal control hardware that is an integral part (e.g., insulation) of the aerobrake is included in the aerobrake subsystem. Typical hardware in this subsystem are insulation, heating and cooling, heat disposal, electronic thermal control and consumable storage and supply.

1.2.11 Aerobrake

1.3.11 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Aerobrake subsystem. This element includes the frame, fairings, stabilizers, aerodynamic surface, substructures, supports, mechanisms and thermal protection associated with the aerobrake.

1.2.12 Ground Support Equipment
1.3.12 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Ground Support Equipment. This element includes those hardware items used to support, manipulate and test subsystem items. These hardware items are limited to manufacturing and launch site ground processing activities.

1.2.13 Airborne Support Equipment (Launch Vehicle)
1.3.13 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Airborne Support Equipment. This element includes those hardware items required to mate the OTV with the launch vehicle (e.g., STS) and separate from it. Included are such items as structural, mechanical equipment, fluid systems, electrical, avionics equipment that provide payload interfaces while the payload is in the payload bay and remate hardware used for OTV retrieval.

1.2.14 Space Support Equipment
1.3.14 "

This hardware element sums all efforts and materials required for design, development, production, and operation of the Space Support Equipment subsystem. This element includes the space based hardware items required to integrate and checkout the systems of an OTV stage. These hardware items are generally limited to special tooling and handling requirements while the stage is on orbit.

1.2.15 Propellant
1.3.15 "

This hardware element includes all flight propellants, all power systems fuels and oxidizers, pressurants, purging gases, and fluids. Propellant totals include annual base requirements plus total flight requirements. Included are all types of propellant required to support the mission.

1.4.0 Space Support Equipment (Space Station)

This hardware element sums all efforts and materials required for design, development, production and operation of the Space Support Equipment system. This element contains the space based hardware items required to support, manipulate, and checkout the systems into an OTV vehicle which cannot be allocated to individual hardware elements below the system level.

1.5.0 Payload Clustering Structure

This hardware element sums all efforts and materials required for design, development, production and operation of the Payload Clustering Structure system. This element includes those hardware items required to mate single or multiple payloads with the OTV. Included are such items as structural and mechanical equipment, fluid systems, electrical and avionics equipment that provide OTV/payload interfaces while the payload is attached to the OTV and while it is docking or being deployed during a mission.

1.6.0 Interstage

This hardware element sums all efforts and materials required for design, development, production and operation of the Interstage system. This element includes those hardware items associated with mating/demating of the OTV stages. Included are such items as structural and mechanical equipment, fluid systems, electrical and avionics equipment that provide an interface between the stages.

1.7.0 Kits

This hardware element sums all efforts and materials required for design, development, production and operation of the kits required to support the special requirements of payloads flown on OTV. Included are such items as structural and mechanical equipment, fluid systems, electrical and avionics equipment that provide tailored utilities to the payloads.

1.8.0 GSE

This hardware element sums all efforts and materials required for design, development, production and operation of the GSE for the total OTV which cannot be allocated to individual hardware elements below the system level. This element includes all hardware items used to support, manipulate and test the OTV vehicle.

1.9.0 Software

This element sums all efforts and materials required for the design, development, test, evaluation and maintenance of software beyond the immediate OTV stage on board flight and communications requirements.

2.0.0 Facilities

This hardware element sums all effort and materials required for design, development, construction/modification and activation of the facilities. This element is subdivided into the following:

2.1.0 Manufacturing/Refurbish

2.2.0 Test

2.3.0 Launch

2.4.0 Mission

2.5.0 Space Station Service

2.6.0 Space Propellant Storage

2.1.0 Manufacturing/Refurbishment

This hardware element sums all efforts and materials required for design, development, construction/modification and activation of the manufacturing and refurbishment facilities. This element includes manufacturing and refurbishment facilities for the launch vehicle hardware elements and propellants.

2.2.0 Test

This hardware element sums all efforts and materials required for design, development, construction/modification and activation of the test facilities.

2.3.0 Launch

This hardware element includes all efforts and materials required for design, development, construction/modification and activation of the ground based launch facilities. This element includes transportation equipment, stage processing facilities, vehicle integration facilities, launch servicing facilities, etc.

2.4.0 Mission

This hardware element sums all efforts and materials required for the design, development, construction/ modification and activation of the mission control facilities. This element includes facilities required to monitor the mission at the various operational levels and provides information required to control, direct, and evaluate the mission from prelaunch checkout through recovery.

2.5.0 Space Station Servicing and Storage

This hardware element sums all efforts and materials required for the design, development, construction/modification and activation of the Space Station Service facilities. This element includes dedicated facilities required to repair and maintain the OTV between missions as well as stage processing, vehicle integration and launch servicing facilities. Typical facilities required include docking adapters, manipulator arms, and storage bays.

2.6.0 Space Propellant Storage

This hardware element sums all efforts and materials required for the design, development, construction/modification and activation of the Space Propellant Storage Facilities. This element includes dedicated facilities required to store and dispense propellant to the OTV to meet mission requirements. Typical facilities required are modification to the Space Propellant Storage Facility to accommodate OTV propellant loading such as special docking adapters, RMS arms and umbilicals.

5.0 PHASE AND FUNCTION DIMENSION

The phase dimension is divided into three major phases: design, development, test, and evaluation (DDT&E); production; and operations. The phases are subdivided into subfunctions such as systems engineering and integration, design and development, tooling, flight hardware, program support, etc. An illustration of a typical WBS for each phase is shown in Figures 3, 4, and 5. Definitions of the individual elements are contained in the following pages.

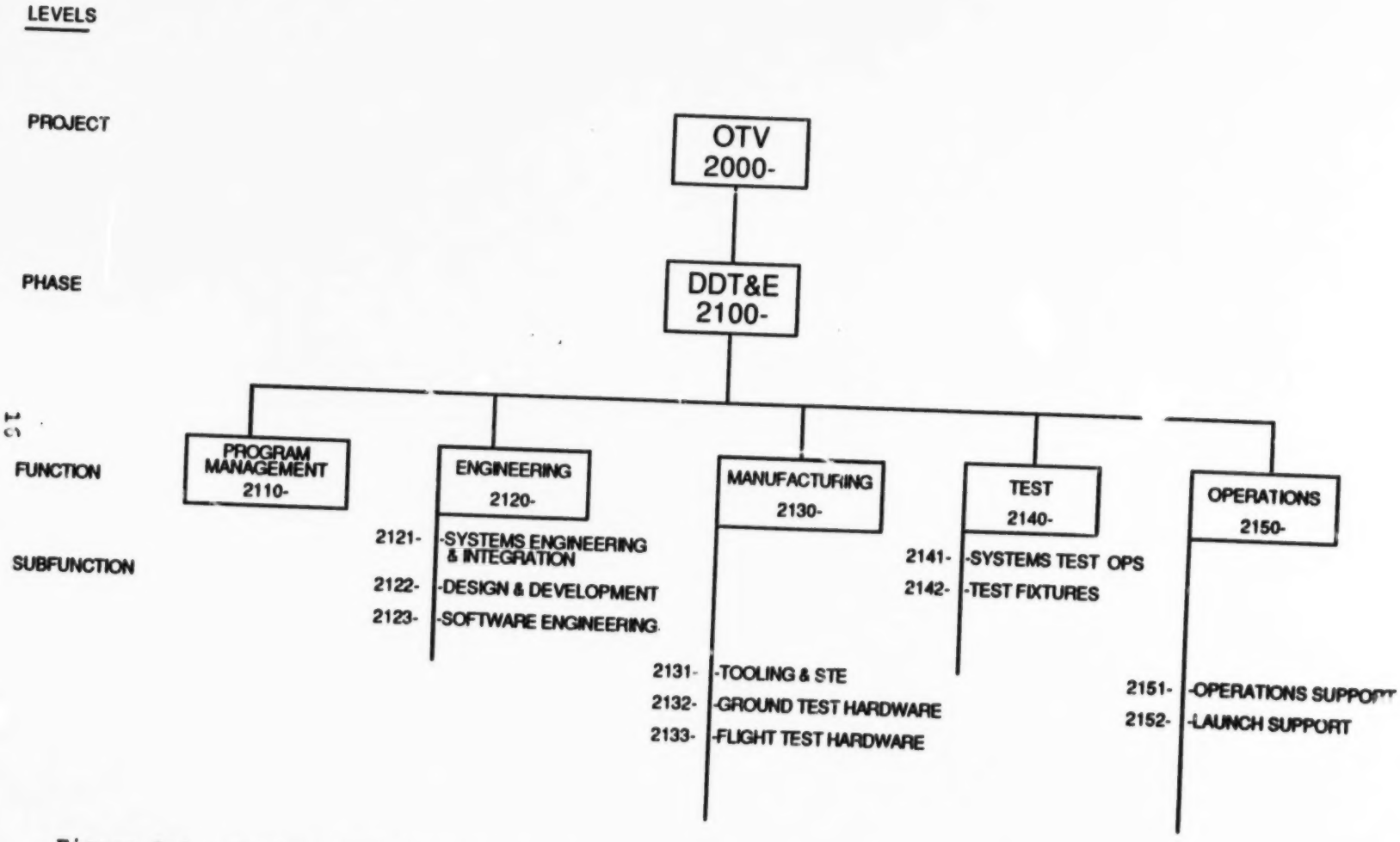

Figure 5-1 Design, Development, Test & Engineering (DDT&E) WBS Phase & Function Dimension

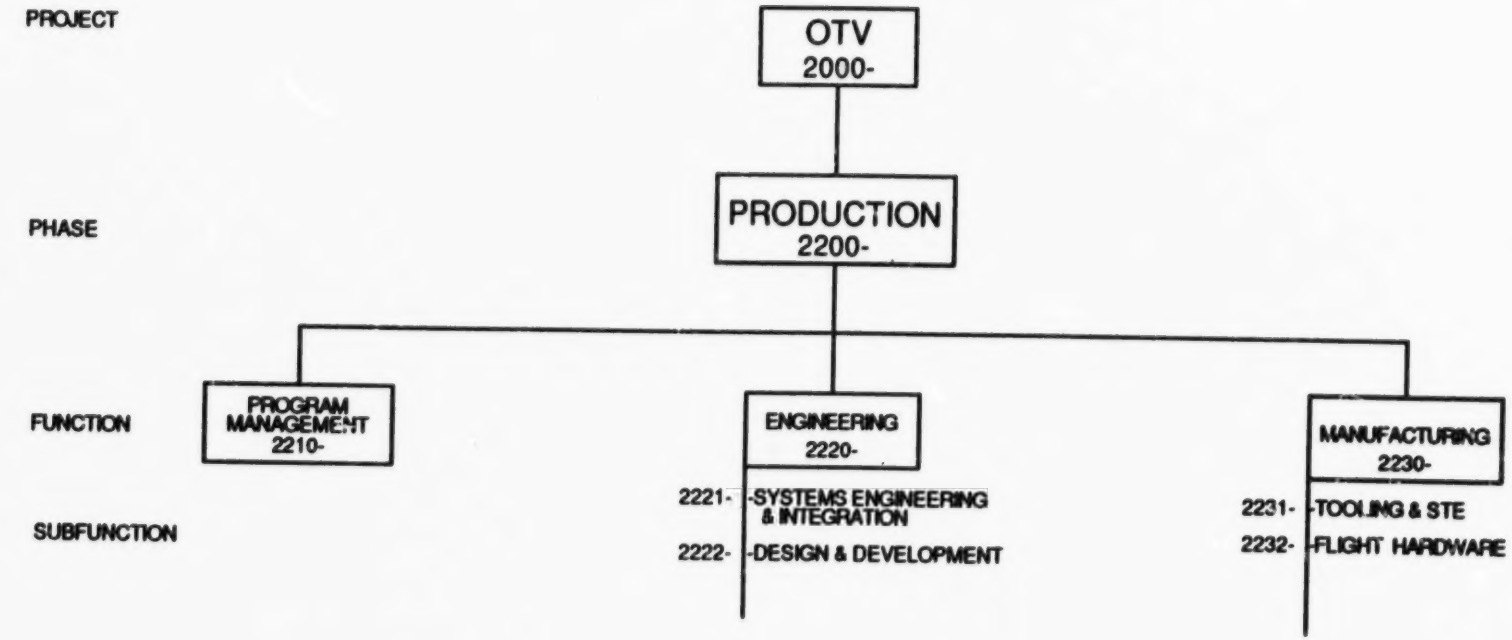

Figure 5-2 Production WBS Phase & Function Dimension

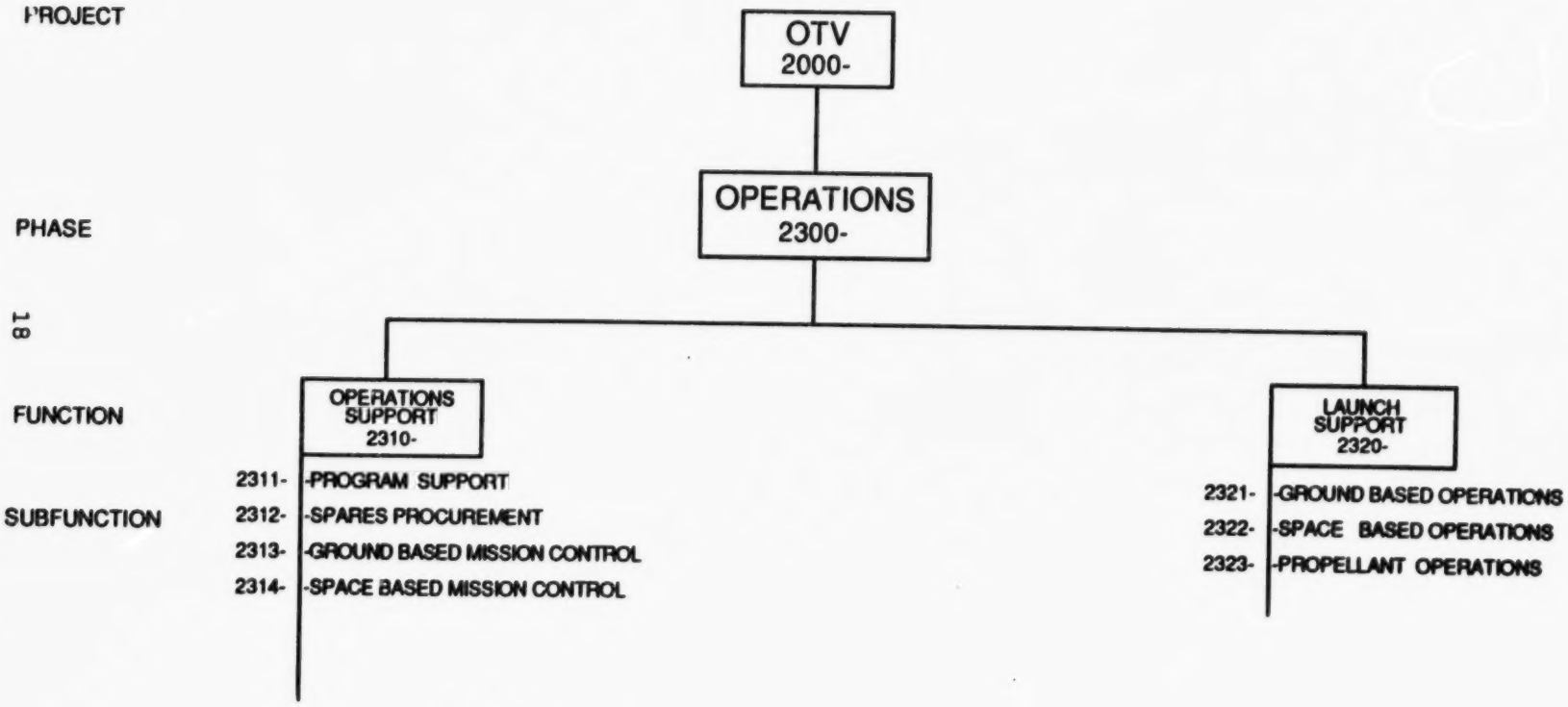

Figure 5-3 Operations WBS Phase & Function Dimension

6.0 DEFINITIONS OF PHASES AND FUNCTIONS

1.0.0.0 OTV Program

This element sums all efforts and materials required for development, production, and operations of the total OTV program.

1.1.0.0 DDT&E - DDT&E Phase

This phase encompasses those tasks associated with the DDT&E phase of the vehicle program and with the requirement for demonstrating the vehicle's performance capabilities.

1.1.1.0 Program Management

1.1.2.0 Engineering

1.1.3.0 Manufacturing

1.1.4.0 Test

1.1.5.0 Operations

Specifically, it includes: mission analysis and requirements definition; mission and support hardware functional definition and design specification; design support; test hardware manufacture; functional, qualification and flight test effort. Also included are special test equipment and development tooling; mission control and/or launch site activation (if required); logistics, training (that is not covered in operations), developmental spares and other program peculiar costs not associated with repetitive production.

1.1.1.0 Program Management - DDT&E Phase

This DDT&E element includes all efforts and materials required for management and fundamental direction to ensure that a quality product is produced and delivered on schedule and within budget. Specific lower level items that are included are:

Program Administration

Program Planning and Control

Contracts Administration

Engineering Management

Manufacturing Management

Support Management

Quality Assurance Management

Configuration Management

Data Management

These items sum all efforts required to provide direction and control of the development of the system, including the efforts required for planning, organizing, directing, coordination, and controlling the project to ensure that overall project objectives are accomplished.

1.1.2.0 Engineering - DDT&E Phase

This DDT&E element includes all efforts and materials associated with analysis, design, development, evaluation, and redesign for specified hardware element items. This element is subdivided into the following lower elements:

1.1.2.1 Systems Engineering and Integration

1.1.2.2 Design and Development Engineering

1.1.2.3 Software Engineering

1.1.2.1 Systems Engineering and Integration - DDT&E Phase

This DDT&E element includes the engineering efforts related to the establishment of a technical baseline for a system by generation of system configuration parameters, criteria, and requirements. Specifically included are:

Engineering Analysis and Systems Integration

Human and Value Engineering

Logistics and Training

Safety, Reliability, Maintainability and Quality Assurance Requirements

1.1.2.2 Design and Development Engineering - DDT&E Phase

This DDT&E element includes all efforts associated with analysis, design, development, evaluation, and redesign necessary to translate a performance specification into a design. Specifically included are the preparation of specification and fabrication drawings, parts lists, wiring diagrams, technical coordination between engineering and manufacturing, vendor coordination, data reduction, and engineering related report preparation. This element can be further subdivided into the following:

Structures

Mechanical

Electrical

Propulsion

Aerodynamics

1.1.2.3 Software Engineering - DDT&E Phase

This DDT&E element includes the cost of the design, development, production, checkout, maintenance and delivery of computer software. Included are ground test, on-board and mission or flight software.

1.1.3.0 Manufacturing - DDT&E Phase

This DDT&E element includes the efforts and materials required to produce the various items of test hardware required by the program which include inspection assembly and checkout of tools, parts, material, subassemblies, and assemblies. The testing of this hardware is accomplished under system test operations. The test articles considered under this element include development models, engineering models, design verification units, qualifications models, structural test units, thermal models, mechanical models, and prototypes. This element is further subdivided into the following:

1.1.3.1 Tooling and STE

1.1.3.2 Ground Test Hardware

1.1.3.3 Flight Test Hardware

1.1.3.1 Tooling and STE - DDT&E Phase

This DDT&E element includes all efforts and materials associated with the planning, design, fabrication, assembly, inspection, installation, modification, maintenance, and rework of all tools, dies, jigs, fixtures, guages, handling equipment, work platforms, and special test equipment necessary for manufacture of the DDT&E vehicles.

1.1.3.2 Ground Test Hardware - DDT&E Phase

This DDT&E element includes all efforts and materials required to produce the various items of required ground test hardware. This element includes processing, subassembly, final assembly, reworking, and modification and installation of parts and equipment. Ground test hardware includes such items as static and dynamic test models, thermal and (if required) firing test articles and the qualification test unit. Also included are those costs chargeable to the acceptance testing, quality control program, and assembly as related to ground test hardware.

1.1.3.3 Flight Test Hardware - DDT&E Phase

This DDT&E element includes all efforts and materials required to produce the various items of flight test hardware. This element includes the same basic operations as defined in WBS item number 1.2.3.2 (Ground Test Hardware).

1.1.4.0 Test - DDT&E Phase

This DDT&E element includes all efforts and materials required for qualifications, integration, and system/subsystem development tests, including the design and fabrication of special test fixtures. This element is further subdivided into the following:

1.1.4.1 Systems Test Operations

1.1.4.2 Test Fixtures

1.1.4.1 Systems Test Operations - DDT&E Phase

This DDT&E element includes all efforts and materials required for assemblies, subsystems, and systems to determine operational characteristics and compatibility with the overall system and its intended operational/non-operational environment. Such tests include design feasibility tests, design and integrated systems to verify whether they are unconditionally suitable for their intended use. These tests are conducted on hardware that have been produced, inspected, and assembled by established methods. Tests performed by two or more contractors to substantiate the feasibility compatibility are also included as well as test planning and scheduling, data reduction and report preparation.

1.1.4.2 Test Fixtures - DDT&E Phase

This DDT&E element includes all the efforts and materials required for the design and fabrication of the unique test fixtures required to support a given system/subsystem test.

1.1.5.0 Operations - DDT&E Phase

This DDT&E element includes all efforts and materials required to operate the hardware defined in the corresponding hardware elements during flight test operations. Also included are the design, construction, and operation of the launch, mission, and recovery facilities required for DDT&E test flights. This element further subdivides into the following:

1.1.5.1 Operations Support

1.1.5.2 Launch Support

1.1.5.1 Operations Support - DDT&E Phase

This element includes all efforts and materials required to support the DDT&E flight test program. This item includes the operation of the mission control facilities and equipment. Included is mission control monitoring which provides the information required to control, direct, and evaluate the mission from prelaunch through recovery.

1.1.5.2 Launch Support - DDT&E Phase

This operations element includes all efforts and materials required to support launch and recovery operations during the DDT&E flight test program. Included are those efforts and materials associated with the receipt of the major hardware categories of the mission hardware. This element does not include payload integration. Included are subelements such as ground operations (including recovery) and propellant operations.

1.2.0.0 Production - Production Phase

This phase includes all efforts and materials required for the production of the reusable flight hardware to meet the total operational requirements. This includes the production of initial spares, but excludes the operational spares as they are included under the operations phase. Specifically this phase includes the following functions:

1.2.1.0 Program Management
1.2.2.0 Engineering
1.2.3.0 Manufacturing

1.2.1.0 Program Management - Production Phase

This element includes all efforts and materials required to ensure fundamental direction, and to make decisions to ensure that a quality product is produced and delivered on schedule and within budget. Specifically included are program administration, program planning and control, contracts administration, engineering management, manufacturing management, project management, and documentation. This item sums all efforts required to provide direction and control of the production of the system, including the efforts required for planning, organizing, direction, coordination, and controlling the project to ensure that overall project objectives are accomplished. These efforts overlay the other functional categories and assure that they are properly integrated.

1.2.2.0 Engineering - Production Phase

This element includes those sustaining engineering efforts and materials necessary to facilitate production and to resolve day-to-day production problems. This element includes the following:

1.2.2.1 Systems Engineering and Integration

1.2.2.2 Design and Development Engineering

1.2.2.1 Systems Engineering and Integration - Production Phase

This element includes the recurring engineering efforts related to the maintenance of a technical baseline for systems configuration parameters, criteria, and requirements. This baseline may include specifications, procedures, reports, technical evaluation, software, and interface definition. This element also includes those efforts required to monitor the system during production to ensure that the hardware conforms to the baseline specifications.

1.2.2.2 Design and Development Engineering - Production Phase

This element includes all recurring efforts and materials associated with sustaining engineering required during the production of the reusable flight hardware and initial spares.

1.2.3.0 Manufacturing - Production Phase

This element includes all recurring efforts and materials associated with the production of reusable flight hardware, initial spares, tooling, and special test equipment (STE).

1.2.3.1 Tooling and STE

1.2.3.2 Reusable Flight Hardware

1.2.3.1 Tooling and STE - Production Phase

This element includes the fabrication of production tooling and those sustaining efforts necessary to facilitate production and to resolve production problems involving tooling and STE. This element also includes the production and/or procurement of replacement parts and spares.

1.2.3.2 Flight Hardware - Production Phase

This element includes all efforts and materials required to produce production flight units. This item includes time expended on, or chargeable to, such operations as fabrication processing, subassembly, final assembly, reworking, modification, and installation of parts and equipment (including Government furnished equipment). Included are those costs chargeable to the acceptance testing, quality control program, and assembly as related to flight units.

1.3.0.0 Operations - Operations Phase

This phase includes those efforts and materials associated with the receipt of the flight hardware at the launch site and the processing, testing, and integration required to prepare for and launch the mission hardware and recovery. This phase also includes reusable hardware spares procurement to support hardware refurbishment and replenishment operations, initial spares procurement and GSE maintenance. This element is subdivided into the following:

1.3.1.0 Operations Support

1.3.2.0 Launch Support

1.3.1.0 Operations Support - Operations Phase

This operations element includes the efforts and materials required to support the operational program. This item includes the operations and program support of the ground based and space based mission control facilities and equipment. It includes spares procurement to support hardware refurbishment and replenishment operations, and GSE Maintenance. This element is subdivided into the following:

1.3.1.1 Program Support

1.3.1.2 Spares Procurement

1.3.1.3 Ground Based Mission Control

1.3.1.4 Space Based Mission Control

1.3.1.1 Program Support - Operations

This operations element includes efforts and materials required to support the operational program. Included are the hardware/mission control center effort and the associated contractor effort to support the operations phase of the program. Mission planning, mission control, sustaining engineering and program management activities for hardware delivery in direct support of the program are included as well as the indirect effort required to support the program or provide multi-program support which must be pro-rated to the program. Both civil service and support contractor effort at the hardware/mission control centers are included. This item includes such functions as:

Management Systems
Operations and Maintenance of Computers and Terminals
Systems Engineering Support Requirements
Documents
Flight Planning Support
National Weather Service
Sustaining Engineering

1.3.1.2 Spares Procurement - Operations Phase

This operations element includes all production, refurbishment and spares cost of the reusable components as well as production of the expendable hardware disposed of during the operational phase of the program.

1.3.1.3 Ground Based Mission Control - Operations Phase

This operations element includes all ground based efforts and materials required to support the mission after ground based or space based launch. This effort includes all ground based mission control operations, simulator operations, engineering support and program management dedicated to the OTV. Ground based launch vehicle (e.g., STS, ACC) mission control costs are not included in this category (see Ground Based Operations).

1.3.1.4 Space Based Mission Control - Operations Phase

This operations element includes all space based efforts and materials required to support the mission after ground based or space based launch. This effort includes all space based mission control operations dedicated to the OTV. Space based maneuvering vehicle (i.e., OMV) mission control costs are not included in this category (see Space Based Operations).

1.3.2.0 Launch Support - Operations Phase

This operations element includes all the efforts and materials required for launch support. This element includes those efforts and materials associated with the receipt of the major hardware elements at the launch location, whether ground based or space based, and the processing, testing, and integration required for preparation and launch of the mission hardware. This element does not include payload integration. Further sub elements are:

1.3.2.1 Ground Based Operations

1.3.2.2 Space Based Operations

1.3.2.3 Propellant Operations

1.3.2.1 Ground Based Operations - Operations Phase

This operations element includes all ground based efforts and materials required for the receipt of the vehicle hardware at the launch site, the processing, testing, and integration required to prepare for launching of the mission hardware as well as ground based operations necessary to carry the OTV to orbit (e.g., STS, ACC).

1.3.2.2 Space Based Operations - Operations Phase

This operations element includes all space based efforts and materials required for the receipt of the vehicle hardware at the launch site (e.g., Space Station), the processing, testing, and integration required to prepare for launching of the mission hardware. This effort includes operation and maintenance of launch related space support equipment, offline systems activities (shops, labs, etc.) required to support the vehicle turnaround activities, as well as direct and indirect contractor activities at the launch site including a prorata share of the base support functions.

1.3.2.3 Propellant Operations - Operations Phase

This operations element includes all flight propellant costs at the launch site such as all fuel and oxidizers, pressurants, purging gases and fluids to support the operational phase of the program. These costs reflect annual base requirements in addition to total flight requirements.